

Claims:

- 1 1. An optical switch comprising:
2 a plurality of input/output ports for receiving one or more
3 wavelength component(s) of an optical signal; and
4 an optical arrangement directing said wavelength component to any
5 given one of the plurality of input/output ports, said given input/output port being
6 variably selectable from among any of the plurality of input/output ports.
- 1 2. The optical switch of claim 1 wherein said optical signal is a broadband
2 signal and said optical arrangement is wavelength-independent.
- 1 3. The optical switch of claim 1 wherein said optical arrangement retroreflects
2 said wavelength component.
- 1 4. The optical switch of claim 2 wherein said optical arrangement retroreflects
2 said broadband signal.
- 1 5. The optical switch of claim 1 wherein said optical signal includes a
2 plurality of wavelength components and said optical arrangement comprises:
3 at least one wavelength selective element selecting one of said
4 wavelength components from among the plurality of wavelength components; and
5 a plurality of optical elements each associated with one of the
6 wavelength selective elements, each of said optical elements directing the selected
7 wavelength component selected by the associated selective element to a given one
8 of the plurality of input/output ports independently of every other wavelength
9 component, said given input/output port being variably selectable from among any
10 of the plurality of input/output ports.

- 1 6. The optical switch of claim 1 further comprising a free space region
2 disposed between the input/output ports and the optical arrangement.
- 1 7. The optical switch of claim 5 further comprising a free space region
2 disposed between the input/output ports and the wavelength selective elements.
- 1 8. The optical switch of claim 5 wherein said wavelength selective elements
2 are thin film filters each transmitting therethrough a different one of the
3 wavelength components and reflecting the remaining wavelength components.
- 1 9. The optical switch of claim 8 wherein said wavelength selective elements
2 are bulk diffraction gratings.
- 1 10. The optical switch of claim 5 wherein said optical elements are reflective
2 mirrors that are selectively tiltable in a plurality of positions such that in each of
3 the positions the mirrors reflect the wavelength component incident thereon to any
4 selected one of the input/output ports.
- 1 11. The optical switch of claim 10 wherein said reflective mirrors are part of a
2 micro-electromechanical (MEM) retroreflective mirror assembly.
- 1 12. The optical switch of claim 11 wherein said retroreflective mirror assembly
2 includes an aspheric lens.
- 1 13. The optical switch of claim 12 wherein said retroreflective mirror assembly
2 includes a curved reflector element.
- 1 14. The optical switch of claim 10 wherein said reflective mirrors are part of a
2 retroreflective optical assembly.

1 15. The optical switch of claim 10 wherein said reflective mirrors each include
2 a piezoelectric actuator.

1 16. The optical switch of claim 7 wherein said free space region comprises an
2 optically transparent substrate having first and second parallel surfaces, said
3 plurality of wavelength selective elements being arranged in first and second arrays
4 extending along the first and second parallel surfaces, respectively.

1 17. The optical switch of claim 15 wherein the optically transparent substrate
2 includes air as a medium in which the optical signal propagates.

1 18. The optical switch of claim 16 where the optically transparent substrate is
2 silica glass.

1 19. The optical switch of claim 16 wherein said first and second arrays are
2 laterally offset with respect to one another.

1 20. The optical switch of claim 19 wherein each of said wavelength selective
2 elements arranged in the first array direct the selected wavelength component to
3 another of said wavelength selective elements arranged in the second array.

1 21. The optical switch of claim 7 wherein the plurality of wavelength selective
2 elements are arranged in a closed configuration.

1 22. The optical switch of claim 21 wherein said closed configuration is a
2 circular configuration.

1 23. The optical switch of claim 21 wherein said free space region defines a
2 polygon.

- 1 24. The optical switch of claim 16 further comprising a focusing mirror
2 arranged in the first array, said focusing mirror reducing insertion loss by adjusting
3 a beam waist location of the optical signal.
- 1 25. The optical switch of claim 23 wherein the free space region is ambient air.
- 1 26. The optical switch of claim 23 wherein the free space region is silica glass.
- 1 27. The optical switch of claim 5 further comprising a collimating lens
2 disposed between each one of said wavelength selective elements and the optical
3 element associated therewith, each of said optical elements being positioned at a
4 focal point of the lens associated therewith.
- 1 28. The optical switch of claim 27 wherein said collimating lens and said
2 optical element serve as a retroreflector.
- 1 29. The optical switch of claim 1 wherein said optical arrangement includes at
2 least one collimating lens and at least one tiltable mirror.
- 1 30. The optical switch of claim 5 wherein said optical elements each include a
2 collimating lens and a tiltable mirror.
- 1 31. The optical switch of claim 1 wherein said optical signal includes first and
2 second pluralities of wavelength components and said optical arrangement includes
3 first and second optical arrangement subassemblies, each of said optical
4 arrangement subassemblies comprising:
5 at least one wavelength selective element selecting one of said
6 wavelength components from among the first or second pluralities of wavelength
7 components; and
8 a plurality of optical elements each associated with one of the
9 wavelength selective elements, each of said optical elements directing the selected

10 wavelength component selected by the associated selective element to a given one
11 of the plurality of input/output ports independently of every other wavelength
12 component, said given input/output port being variably selectable from among any
13 of the plurality of input/output ports.

1 32. The optical switch of claim 31 further comprising an optical coupling
2 arrangement directing the first plurality of wavelength components to the first
3 optical arrangement subassembly and directing the second plurality of wavelength
4 components to the second optical arrangement subassembly.

1 33. The optical switch of claim 32 wherein said optical coupling arrangement
2 includes a filter reflecting the second plurality of wavelength components to the
3 second optical arrangement subassembly and transmitting therethrough the first
4 plurality of wavelength components.

1 34. The optical switch of claim 33 wherein said optical coupling arrangement
2 further includes a prism receiving the first plurality of wavelength components
3 from said filter and directing the first plurality of wavelength components to the
4 first optical arrangement subassembly.

1 35. The optical switch of claim 7 further comprising a focusing mirror arranged
2 in an optical path traversed by the optical signal between a pair of the wavelength
3 selective elements, said focusing mirror reducing insertion loss by adjusting a
4 beam waist location of the optical signal.

1 36. A method for directing a first wavelength component of an optical signal
2 that includes at least one wavelength component from a first input/output port to
3 any selected one of a plurality of input/output ports that includes said first
4 input/output port, said method comprising the steps of:
5 receiving the optical signal at the first input/output port;

- 6 selecting the first wavelength component if the optical signal includes a
7 plurality of wavelength components;
8 selecting a given input/output port from among any of the plurality of
9 input/output ports; and
10 directing the first wavelength component to the given input/output port.
- 1 37. The method of claim 36 wherein the first input/output port and the given
2 input/output port are the same port.
- 1 38. The method of claim 36 wherein the step of directing the first wavelength
2 component includes the step of directing the first wavelength component through a
3 free space region.
- 1 39. The method of claim 36 wherein the step of selecting the first wavelength
2 component includes the step of demultiplexing the first wavelength component
3 with a thin film filter having a passband corresponding to the first wavelength.
- 1 40. The method of claim 38 wherein the first wavelength component is directed
2 through the free space region by a tiltable mirror.
- 1 41. The method of claim 40 wherein the tiltable mirror is a MEM mirror.
- 1 42. The method of claim 41 wherein said MEM mirror is a retroreflective
2 MEM mirror assembly.
- 1 43. The method of claim 36 wherein said optical signal is a broadband optical
2 signal.

1 44. A method for directing at least first and second wavelength components of
2 a WDM signal that includes a plurality of wavelength components from a first
3 input/output port to any selected one of a plurality of input/output ports that
4 includes said first input/output port, said method comprising the steps of:
5 receiving the WDM signal at the first input/output port;
6 selecting the first wavelength component from among the plurality of
7 wavelength components;
8 selecting a given input/output port from among any of the plurality of
9 input/output ports;
10 directing the first wavelength component to the given input/output port; and
11 directing the second wavelength component to another given one of the
12 plurality of input/output ports selected independently from the given input/output
13 port to which the first wavelength component is directed.

1 45. The method of claim 44 wherein the first input/output port and the given
2 input/output port are the same port.

1 46. The method of claim 44 wherein the steps of directing the first and second
2 wavelength components include the steps of directing the first and second
3 wavelength components through a free space region.

1 47. The method of claim 44 wherein the step of selecting the first wavelength
2 component includes the step of demultiplexing the first wavelength component
3 with a thin film filter having a passband corresponding to the first wavelength.

1 48. The method of claim 46 wherein the first wavelength component is directed
2 through the free space region by a tiltable mirror.

1 49. The method of claim 48 wherein the tiltable mirror is a MEM mirror.

1 50. The method of claim 49 wherein said MEM mirror is part of a retroreflector
2 optical assembly.

1 51. The method of claim 48 wherein said tiltable mirror includes a piezoelectric
2 actuator.

1 52. The method of claim 48 further comprising the step of collimating the first
2 wavelength component before it is incident upon the tiltable mirror.

1 53. The method of claim 47 wherein the demultiplexing and directing steps are
2 performed by a plurality of narrow band free space switches.

1 54. The method of claim 53 wherein said free space switches include a
2 retroreflective mirror.

1 55. A method for directing at least first and second wavelength components of
2 a WDM signal that includes a plurality of wavelength components from a first
3 input/output port to any selected ones of a plurality of input/output ports that
4 includes said first input/output port, said method comprising the steps of:

5 (a) demultiplexing the first wavelength component from the
6 WDM signal;

7 (b) directing the first wavelength component to a given
8 input/output port; and

9 (c) demultiplexing the second wavelength component from the
10 WDM signal and directing the second wavelength component to one of the
11 plurality of input/output ports selected independently from the given input/output
12 port.

1 56. The method of claim 55 wherein step (c) is performed subsequent to steps
2 (a) and (b).

00691812-101900

- 1 57. The method of claim 55 wherein the steps of directing the first and second
2 wavelength components include the steps of directing the first and second
3 wavelength components through a free space region.
- 1 58. The method of claim 55 wherein the first wavelength is demultiplexed by a
2 thin film filter having a passband corresponding to the first wavelength.
- 1 59. The method of claim 57 wherein the first wavelength component is directed
2 through the free space region by a tiltable mirror.
- 1 60. The method of claim 59 wherein the tiltable mirror is a reflective mirror.
- 1 61. The method of claim 60 wherein said reflective tiltable mirror includes a
2 piezoelectric actuator.
- 1 62. The method of claim 59 further comprising the step of collimating the first
2 wavelength component onto the tiltable mirror.
- 1 63. The method of claim 55 wherein the demultiplexing and directing steps are
2 performed by a plurality of narrow band free space switches.
- 1 64. The optical switch of claim 5 further comprising a detector associated with
2 each of the wavelength selective elements for monitoring the wavelength
3 component transmitted therethrough.
- 1 65. The method of claim 55 further comprising the step of monitoring the first
2 wavelength component after performing the demultiplexing step.

00601-2785960

- 1 66. An optical switch comprising:
2 a plurality of input/output ports for receiving one or more
3 wavelength components of a WDM signal that includes a plurality of wavelength
4 components; and
5 means for selecting one of said wavelength components from
6 among the plurality of wavelength components and directing the selected
7 wavelength component selected by the associated selective element to a given one
8 of the plurality of input/output ports independently of every other wavelength
9 component, said given input/output port being variably selectable from among any
10 of the plurality of input/output ports.
- 1 67. The optical switch of claim 66 wherein said selecting and directing means
2 comprises a plurality of narrow band free space switches.
- 1 68. The optical switch of claim 66 wherein said selecting and directing means
2 comprises a wavelength selective element and an optical element associated
3 therewith.
- 1 69. The optical switch of claim 68 wherein said wavelength selective element
2 is a thin film filter.
- 1 70. The optical switch of claim 67 wherein said narrow band free space switch
2 includes a thin film filter and a tiltable optical element.
- 1 71. The optical switch of claim 70 wherein said tiltable optical element is a
2 tiltable mirror.
- 1 72. The optical switch of claim 68 wherein said wavelength selective element
2 is a bulk diffraction grating.

00591312-101900

1 81. The optical switch of claim 70 wherein said tiltable optical element
2 includes a tiltable mirror and a collimating lens.

1 82. The optical switch of claim 29 further comprising a correcting optical
2 element disposed between the collimating lens and said tiltable mirror for reducing
3 insertion loss.

1 83. The optical switch of claim 82 wherein said optical element is a tiltable
2 mirror and said correcting optical element is a convex-concave lens.

1 84. The optical switch of claim 83 wherein at least one surface of said convex-
2 concave lens has a spherical radius of curvature substantially equal to a distance
3 between a surface of the lens and the tiltable mirror.

1 85. The optical switch of claim 81 further comprising a correcting optical
2 element disposed between the collimating lens and said tiltable mirror for reducing
3 insertion loss.

1 86. The optical switch of claim 85 wherein said correcting optical element is a
2 convex-concave lens.

1 87. The optical switch of claim 86 wherein said convex-concave lens has a
2 spherical radius of curvature substantially equal to a distance between at least one
3 surface of the lens and the tiltable mirror.

00691812-101900